



High Performance Network Evaluation and Testing

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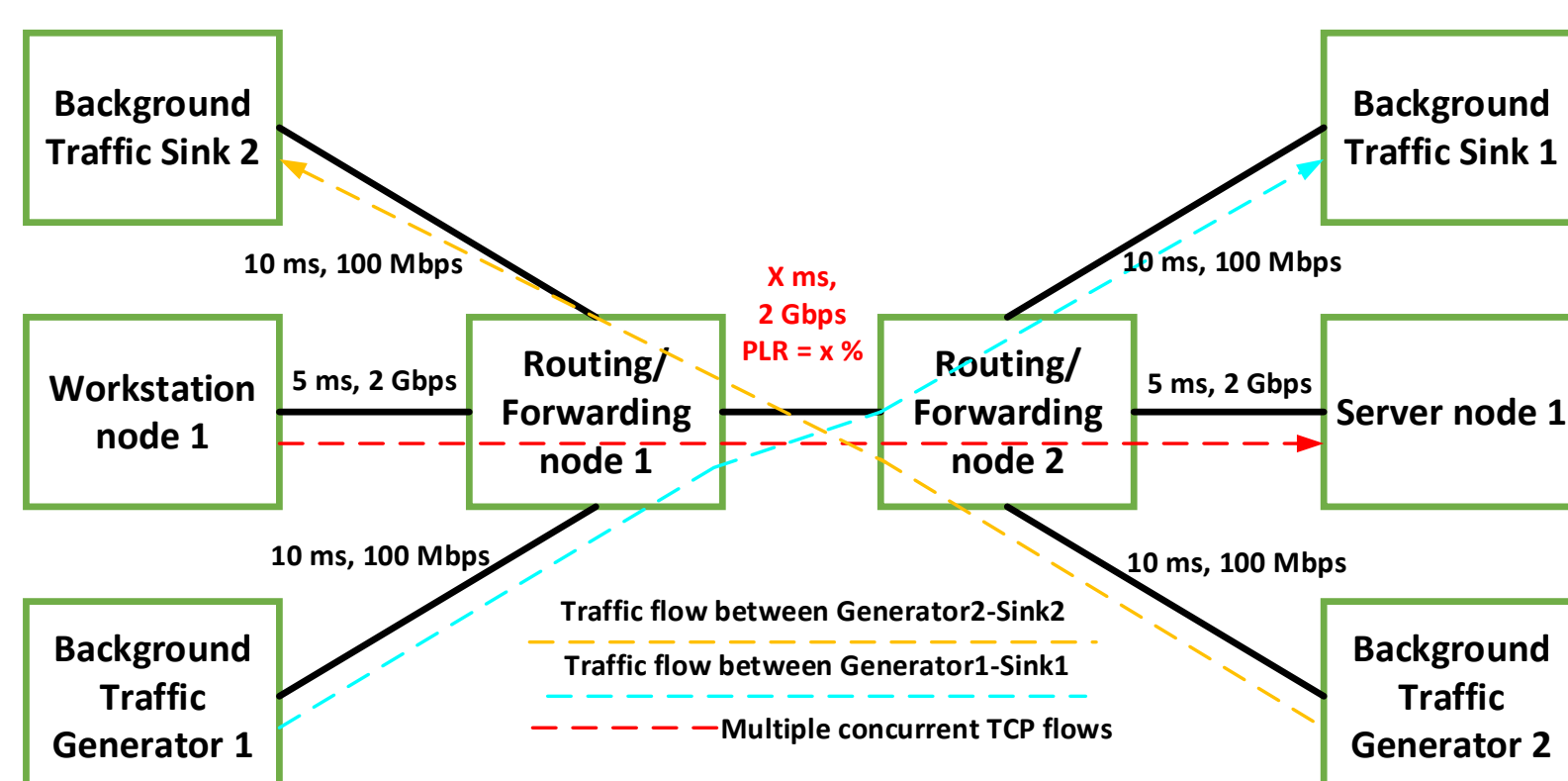
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High Speed TCP connections for performance evaluation

- A major fraction of today's globally generated Internet traffic relies on TCP as a transport protocol, which plays a critical role in ensuring a reliable and connection-oriented transport service (Layer 4).
- Feature-rich and bandwidth-intensive applications (financial/high-frequency trading data, large volumes of experimental research data, multimedia content) require optimized, scalable and efficient algorithms and communication protocols. Efficient TCP Congestion control solutions are of utmost importance.
- As a result, proactive performance evaluation tests must be leveraged in order to characterize the state of the network under different operating conditions (varying workloads, application-specific requirements). Therefore, it is important to ensure that the defined testing scenarios are as close to reality as possible.
- Considering the global Internet as such, a large fraction of servers are Linux-based (successful integration of OpenStack impacts the choice as well) and a currently default system-wide TCP Congestion control algorithm in Linux is a high-speed TCP CUBIC.
- Extensive experimental and simulation-based analysis of this algorithm showed that, despite all the benefits (high scalability, stability), there are several serious drawbacks (controversial RTT- and TCP-fairness, poor performance in wireless environments, loss synchronization). In addition to that, available results are often contradicting.

Complementary simulation-based study of TCP CUBIC

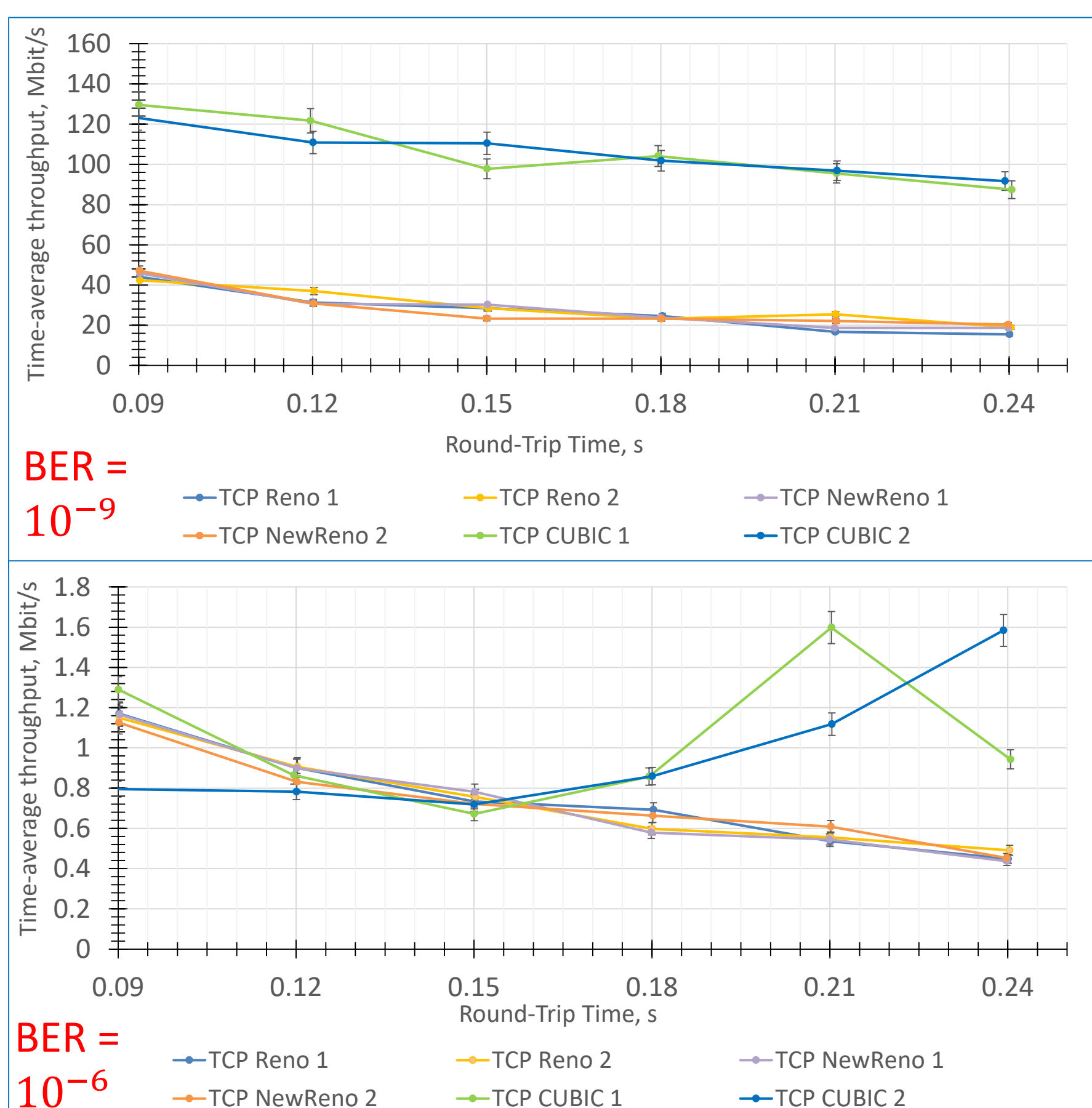
- A simulation-based analysis of TCP CUBIC was conducted in our work in order to gather additional results and to get an insight of the adaptation capabilities and operating robustness of multiple TCP CUBIC connections under severe operating conditions.
- The simulation network setup is a popular dumbbell topology, widely used for analysis of the congestion control algorithms. We considered the following scenarios:
 - Multiple different long-lived TCP connections (TCP CUBIC, Reno, NewReno) in a network environment with a large BDP (Bandwidth-Delay Product), increasing random packet loss rate and increasing RTT (Round-Trip-Time) of the flows.
 - Multiple different long-lived TCP connections in a network with a bottleneck transit link (variable bandwidth), different buffer sizes at the bottleneck and increasing network load (increasing number of TCP CUBIC flows, joining the network). Drop-Tail buffer is used.
- Future work: Evaluation of the impact of SACK, Limited Transmit and ACK Heuristics algorithms on the packet loss recovery efficiency of high-speed TCP CUBIC flows in the network environment with a synchronized packet loss pattern (due to a bottleneck link).



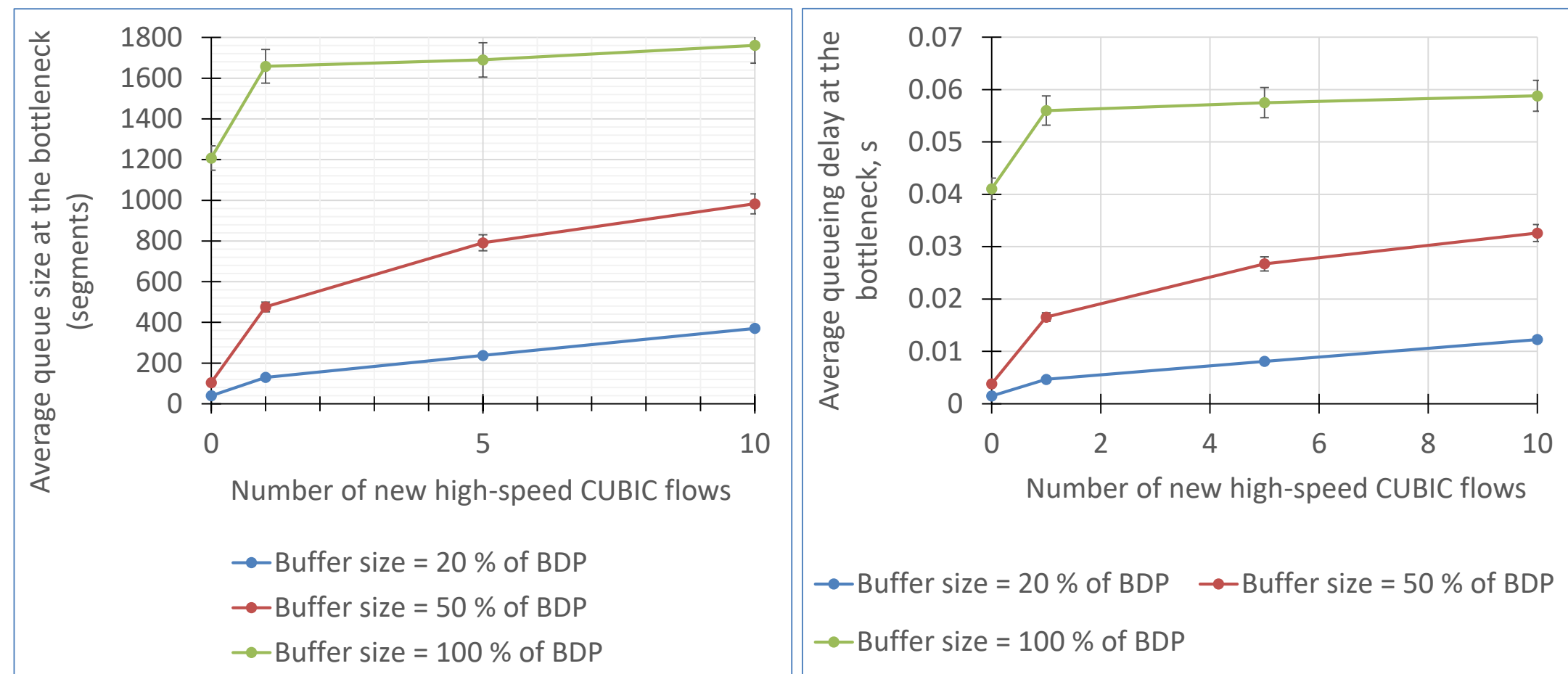
A logical scheme of a Simulation setup

Results

Scenario 1



Scenario 2



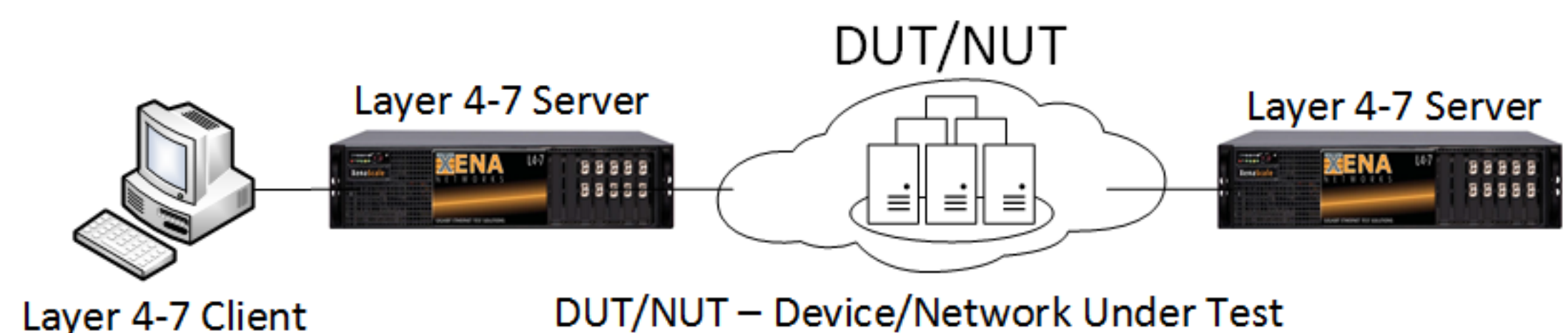
Discussion

- A non-linear and highly scalable window increase algorithm of CUBIC leads to a transmission of large packet bursts in the network environment with random loss, but a constant (deterministic) loss probability p , with $1/p$ packets between two successive loss events. Fast increase of the transmission rate leads to a larger number of randomly dropped packets within a period of time.
- Loss-based approach of congestion control in CUBIC and a loss-free-time-dependent congestion window growth rate, maintain the utilization of the buffer at the maximum level. New high-speed CUBIC flows contribute to the build-up of large packet queues and increased queueing delays.
- Different buffer size settings at the bottleneck node (Router) may alleviate the performance degradation, but at the cost of decreased throughput. Hence, more advanced queue management algorithms will improve the situation to a certain extent.

Large scale network testing: challenges and opportunities

When it comes to real-life network testing as such, in order to be able to perform a large-scale network performance evaluation, there are a few available strategies, but the most realistic one is a emulation of a large number of concurrent TCP connections through a scalable testing platform. Since each established TCP connection, especially when the high-speed TCP flavours are used, maintains relatively large amount of connection state information (TCP Connection Block), significant amount of memory and computational resources might be consumed. If we consider emulation of millions of simultaneous TCP connections (a realistic scenario for a medium-sized backbone or a Data Center Network), multiple scalability problems of a network tester may arise. Thus, several alternative implementations of a TCP protocol stack have been considered, which support only the generic functionality of a TCP connection engine (requiring much less connection state information). An example of such a simplified TCP connection engine is a light-weight-IP (lwIP) stack. While it can be deployed for testing purposes, there are still several important questions to answer: will it be sufficient enough for a realistic network evaluation, and what is a scalability penalty for a high-speed TCP connection testing approach in a resource-constrained tester? These are the questions we would like to answer as a future step in our research. We have considered a L4-7 network testing platform, provided by Xena Networks ApS, as a potential environment for experimental prototyping. It offers the following testing capabilities:

- Scalable Gigabit TCP testing (1 G, 10G and 40G interfaces)
- Stateful Traffic generation (load) with 24 M TCP Clients and 24 M Servers on one platform
- Connection ramp up rate: 12 M connections/s.



Research topics of current interest



Data Center Networks
SDN Energy Efficiency